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Center for Army Analysis

VALUE ADDED ANALYSIS PHASE V

JUNE 2001

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13. ABSTRACT *(Maximum 200 Words)* This project was requested by the Office of the Deputy Chief of Staff for Operations and Plans and the Office of Army Programs Analysis and Evaluation (PA&E). The purpose of the project was to evaluate the costs and benefits of selected weapon systems and to develop and evaluate alternative weapon systems modernization programs.			
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VALUE ADDED ANALYSIS PHASE V (VAA 5)

SUMMARY

THE PROJECT PURPOSE was to evaluate the costs and benefits of selected weapon systems and to develop and evaluate alternative weapon systems modernization programs.

THE PROJECT SPONSOR was the Office of the Deputy Chief of Staff for Operations and Plans, Force Development (DAMO-FD) and the Office of Army Programs Analysis and Evaluation (PA&E).

THE PROJECT OBJECTIVES were to

(1) Determine the marginal effectiveness of selected modernization weapon systems.

(2) Determine the procurement costs of the modernized systems.

(3) Develop and analyze alternative weapon systems modernization programs.

THE SCOPE OF THE PROJECT was limited to modernization weapon systems that could be accurately portrayed in the Eagle combat model.

THE MAIN ASSUMPTIONS were:

(1) Cost data is authoritative for programming purposes.

(2) Survey results accurately reflect decision maker position.

(3) The measures of effectiveness (MOEs) assess the utility of a major weapon system.

THE PRINCIPAL LIMITATIONS are:

(1) Only two scenarios and two timeframes are explicitly modeled.

(2) Not all procurement programs are analyzed.

(3) Effects of training and other readiness issues not modeled.

(4) There is a 2-year lag between procurement and funding.

THE PRINCIPAL FINDINGS are:

(1) The best value for the investment in digitization appears to be at the brigade level, followed by the Army Tactical Command and Control System (ATCCS), then division level.

(2) The High Mobility Artillery Rocket System (HIMARS) is the most commonly nonselected system. This is because it is produced in the same years as systems with a higher cost-benefit ratio.

(3) An improvement to the M1A2 is consistently selected, M1A1D when funds are tight, and M1A2 SEP otherwise.

THE PROJECT EFFORT was conducted by LTC Rodger Pudwill, Resource Analysis Division, Center for Army Analysis (CAA).

COMMENTS AND QUESTIONS may be sent to the Director, Center for Army Analysis, ATTN: CSCA-RA, 6001 Goethals Road, Suite 102, Fort Belvoir, VA 22060-5230.

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1 INTRODUCTION

1.1 Value Added Analysis Phase V (VAA 5)

This project was requested by the Office of the Deputy Chief of Staff for Operations and Plans, Force Development (ODCSOPS-FD) and the Office of Army Programs Analysis and Evaluation (PA&E). The purpose of this project was to evaluate the costs and benefits of selected weapon systems and to develop and evaluate alternative weapon systems modernization programs.

1.2 Purpose

The purpose of this report is to present initial findings and results of the VAA 5 study. It also provides the methodology that was used.

1.3 Assumptions and Limitations

Assumptions

(1) Cost data is authoritative for programming purposes.
(2) Survey results accurately reflect decisionmaker positions.
(3) The measures of effectiveness (MOE) assess the utility of a Major Item System.
(4) There is a 2 year lag between procurement and fielding.

Limitations

(1) Only two scenarios and two timeframes are explicitly modeled.
(2) Not all procurement programs are analyzed.
(3) Effects of training and other readiness issues not modeled

Figure 1. Assumptions and Limitations

The key assumptions and limitations for VAA 5 are listed in Figure 1.

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2 VAA METHODOLOGY AND RESULTS

2.1 VAA Analytical Framework

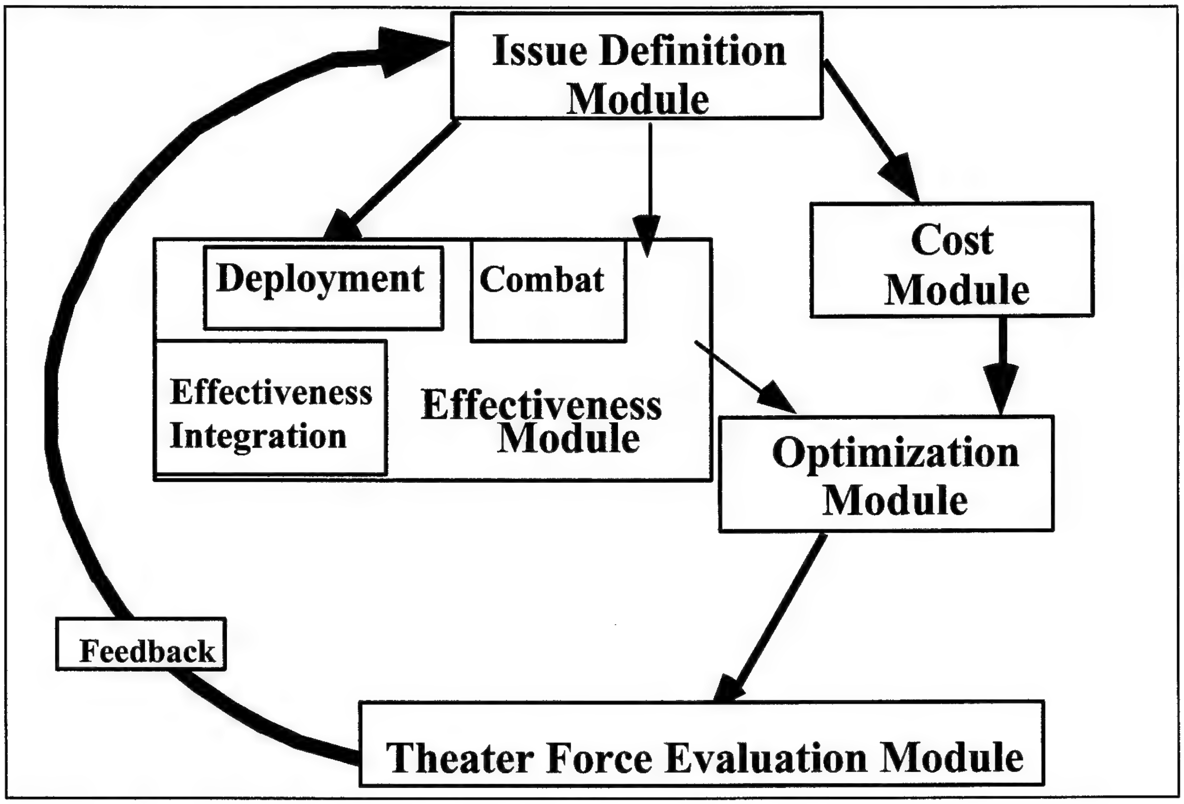


Figure 2. VAA Analytical Framework

Figure 2 gives the framework of the Value Added Analysis (VAA) methodology. The VAA methodology was developed in the late 1980s to address the problem of cross mission area tradeoffs between modernization programs. It consists of a series of subanalyses integrated into a methodology that culminates in the generation of recommended acquisition strategies. The conduct of a VAA study typically consists of an initial long-term project followed by a series of quick reaction analyses (QRAs). The long-term project is designed to develop the cost and effectiveness information necessary to support the analysis of the issues in the current Program Objective Memorandum (POM) decision cycle. The follow-on QRAs then address specific questions and concerns. This report will discuss the long-term portion of the analysis.

Each of the modules, with the exception of the Theater Force Evaluation Module and the Results and Display Module, will be discussed in this report. The two excepted modules were not performed in the VAA 5 study. For a more detailed discussion of the VAA framework, see the research paper written by CAA entitled Value Added Analysis for Army Equipment Modernization (CAA-RP-95-3).

2.2 Issue Definition Module

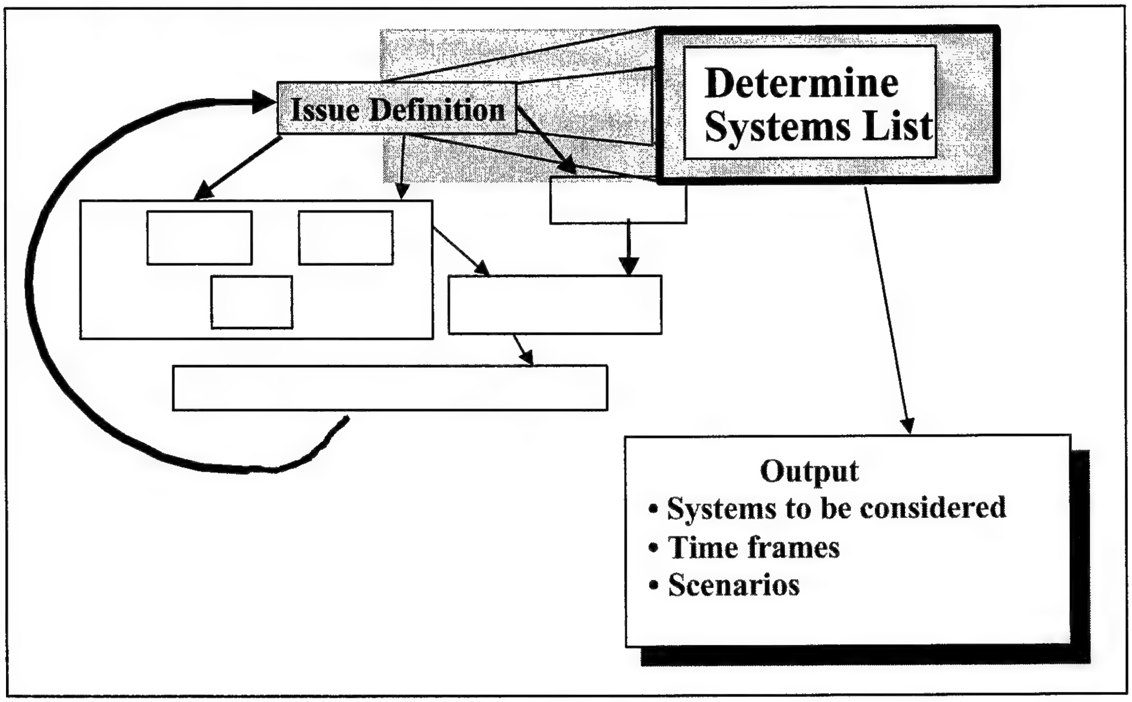


Figure 3. Issue Definition Module

The VAA procedure starts with the determination of the systems to be addressed in the current iteration of VAA. This list is developed in conjunction with the study sponsors. Currently, only 40-50 systems are included in the process; however, the funds required to field these 40 systems represent approximately 50 percent of the total research, development and acquisition (RDA) funding available each year over the 15-year time horizon of the VAA process. The systems were chosen based upon each system's importance, the ability to affect a decision on the procurement of the system, and the ability to accurately portray the system in a combat model. The timeframes, scenarios, and budgets to be examined are also determined.

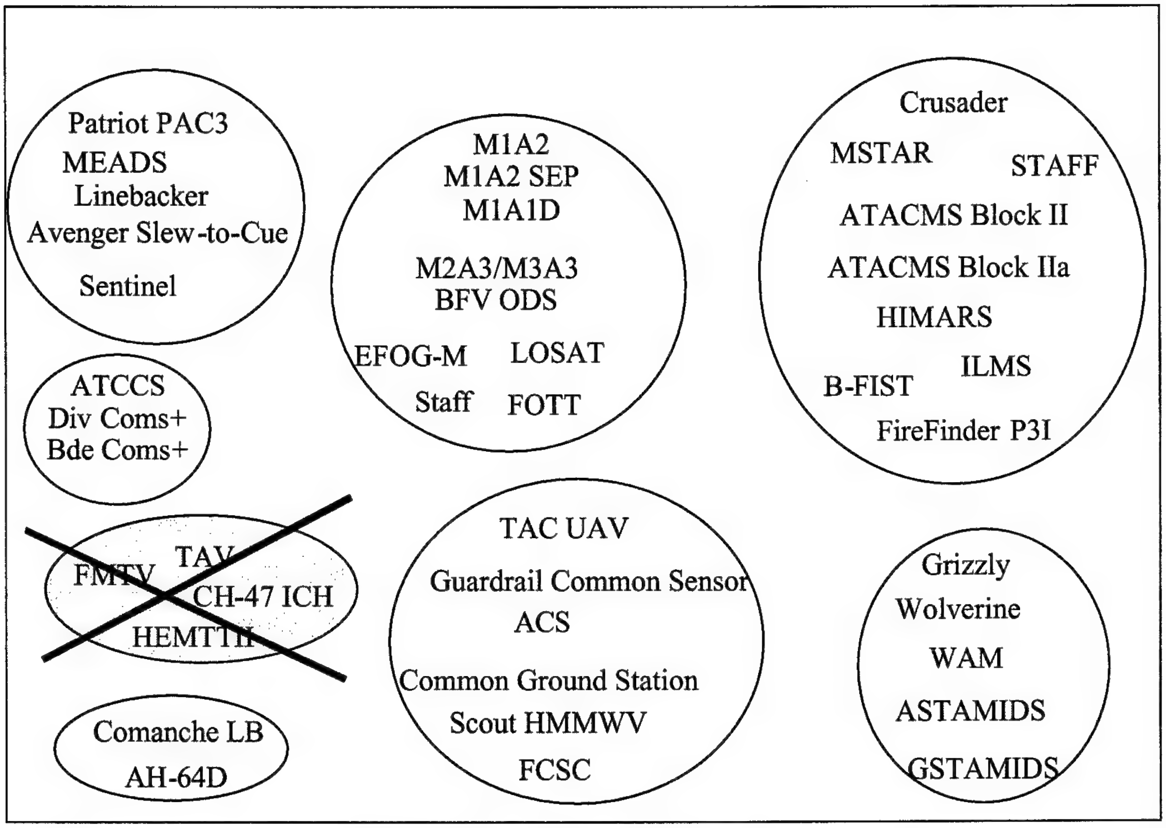


Figure 4. Candidate Systems

The systems listed in Figure 4 were under consideration in VAA 5. They are grouped by battlefield operating system (BOS). Note that the TAV, FMTV, CH-47 ICH, and HEMTT II were initially under consideration, but were later dropped because it was determined that they could not be adequately represented in the combat model.

The full system names are in the following list.

Acronym	System
ACS	aerial common sensor
ASTAMIDS	Airborne Standoff Minefield Detection System
ATACMS_II	Army Tactical Missile System Block II with brilliant antitank technology warhead
ATACMS_IIA	Army Tactical Missile System Extended Range Block IIA with brilliant antitank technology P3I warhead
ATCCS	Army Tactical Command and Control System
Avenger Slew-to-Cue	air defense missile system
BFIST	Bradley fire support vehicle
BdeComs	brigade communications
CH-47 ICH	Chinook - improved cargo helicopter
Comanche LB	Comanche helicopter with Longbow HELLFIRE missile
Crusader	155mm self-propelled howitzer
DivComs	division communications
EFOG-M	enhanced fiber-optic guided missile
FF_P3I	FireFinder II, improved countermortar/counterbattery radar
FMTV	Family of Medium Tactical Vehicles
FOTT	follow-on to TOW
FSCS	Future Scout and Cavalry System
GBCS_AQF	Ground Based Common Sensor - Advanced Quickfix
Grizzly	obstacle clearing equipment
GSTAMIDS	Ground Standoff Minefield Detection System
HELLFIRE	precision guided missile
HEMTT_II	heavy expanded mobility tactical truck - II
HIMARS	High Mobility Artillery Rocket System
ILMS	Improved Launcher Mechanical System
Linebacker	modified Bradley M2A2 Operation DESERT STORM vehicle
LOSAT	line of sight antitank (missile)
LRAS3	long-range scout vehicle
M1A2 SEP	M1A2 tank with Service Life Extension Program
M2A3/M3A3 BFV ODS	Bradley fighting vehicle - A3
MEADS	Medium Air Defense System
MSTAR	Multiple Launch Rocket System Smart Tactical Rocket
PAC_3	Patriot advanced capability-3
Sentinel	air defense radar
STAFF	smart top attack fire and forget munition
TAV	tactical aerial vehicle
TAC UAV	tactical unmanned aerial vehicle
WAM	wide area mine
Wolverine	armor launched bridging unit
AH-64D	Apache attack helicopter
M1A2	tank
M1A1D	tank
GCS	Guardrail common sensor
CGS	common ground sensor
Scout HMMWV	scout high mobility multipurpose wheeled vehicle

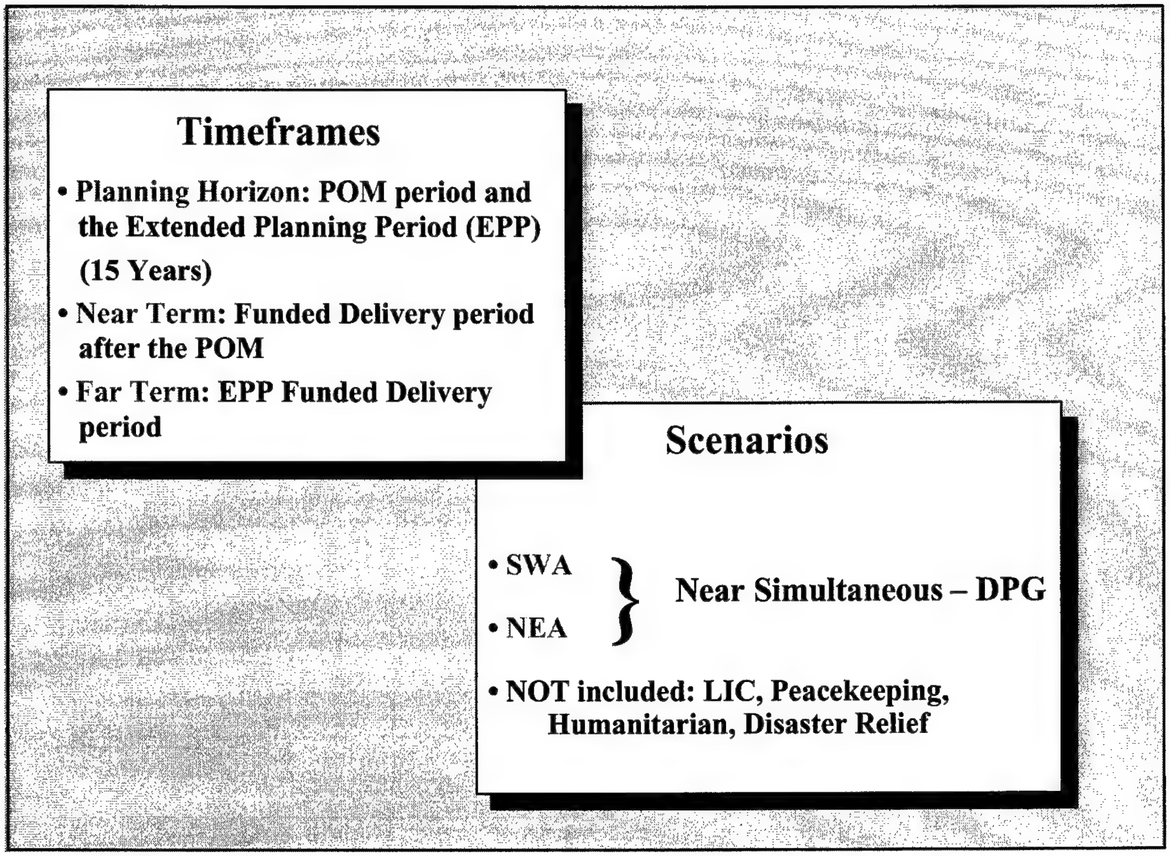


Figure 5. Timeframes and Scenarios

Figure 5 provides the timeframes and scenarios that were used in VAA 5. These are in accordance with the Defense Planning Guidance (DPG). In the scenarios box, LIC means low intensity conflict.

Budget constraints were developed using the research, development, and acquisition (RDA) portion of the total obligation authority (TOA). From the RDA portion, we estimated the percentage that would be allocated for the VAA systems. The budget constraints were $4.6 billion (B) in FY 2000, $5.3B in FY 2001, and $5.6B in FY 02-14.

2.3 Cost Module

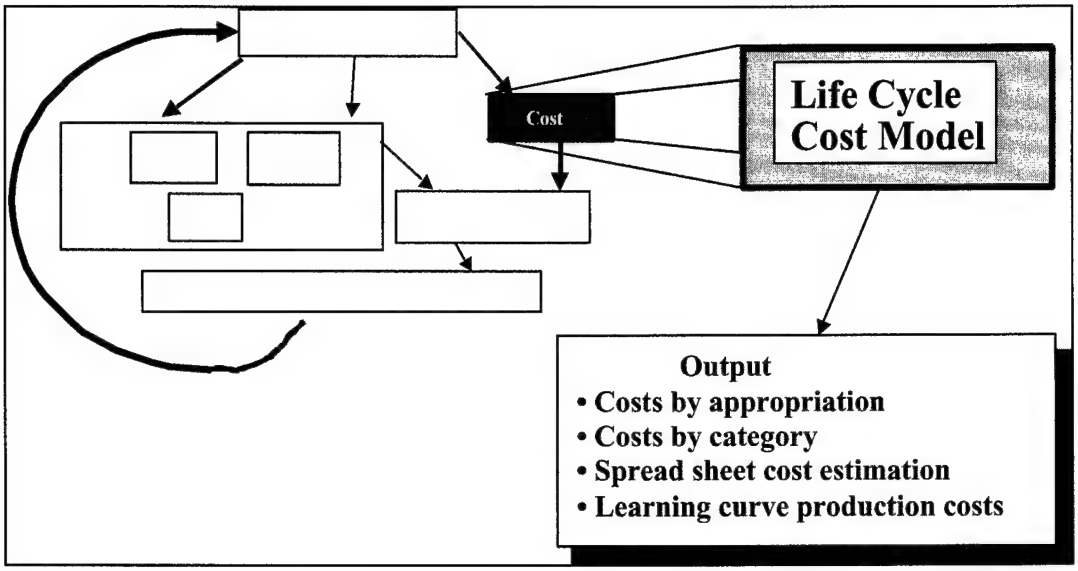


Figure 6. Cost Module

As the primary purpose of the VAA process is to support the building of the Army's Program Objective Memorandum (POM), the initial emphasis in the cost module is on the investment costs required to field a system. However, once a recommended acquisition strategy has been generated, the procedures to generate other cost values of interest (such as life cycle or flyaway costs) are readily available. The investment costs generated in this module are used in the optimization module.

2.4 Effectiveness Module

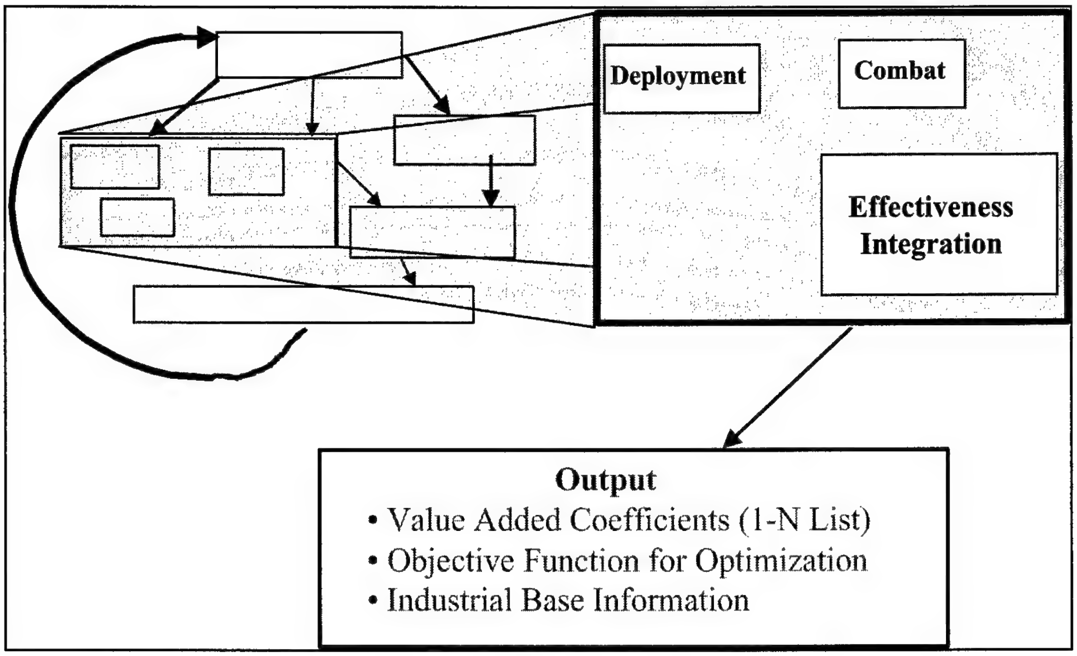


Figure 7. Effectiveness Module

The effectiveness module consists of several submodules, which are discussed in detail below. The end result of this portion of the process is to generate the objective function for the mixed integer optimization program in the last section of the methodology. The work generated in this section is in accordance with the current Defense Planning Guidance that requires that the Services plan to support two major regional contingencies (MRC) which occur nearly simultaneously in time. Currently, two timeframes are examined; near-term--defined as the completion of the funded delivery period after the POM (2007), and far-term--the end of the funded delivery period after the Extended Planning Period (2014/2015).

2.5 Deployability Effectiveness Submodule

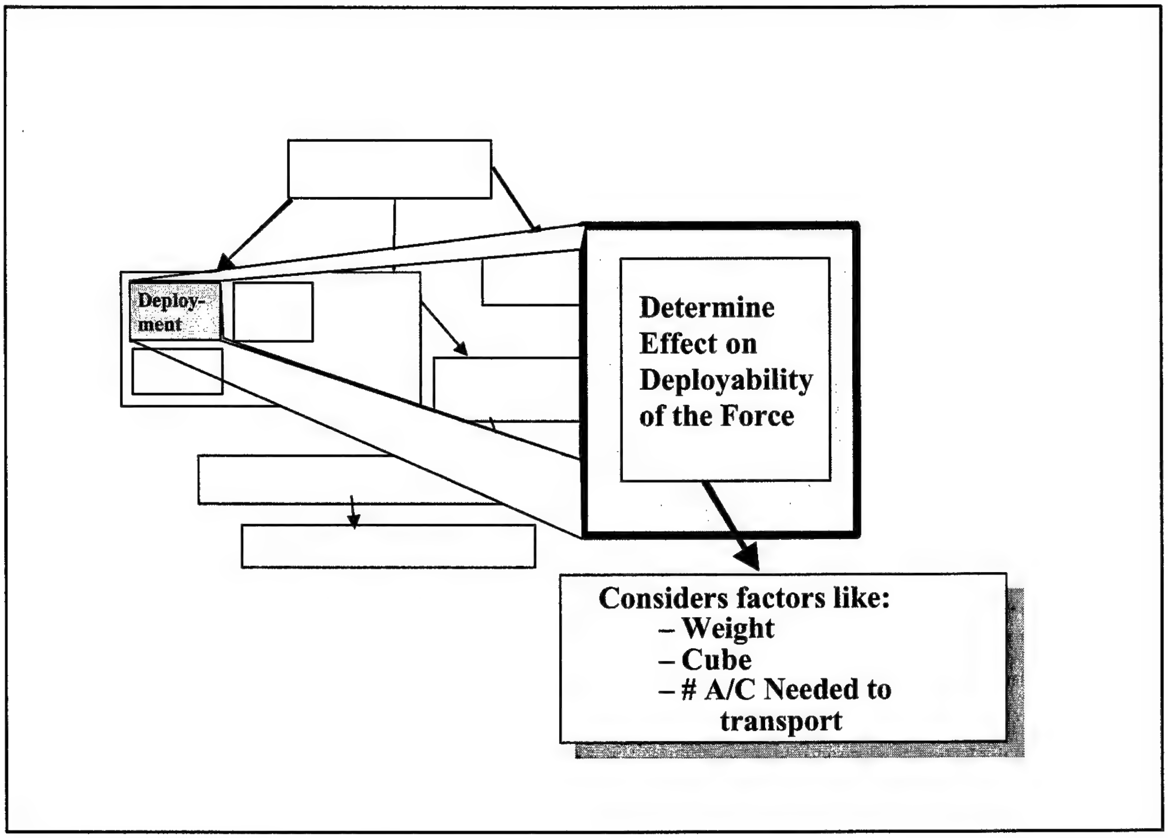


Figure 8. Deployability Effectiveness Submodule

The impact of the new system on the deployment of a unit or force to theater of operations is subcontracted to the Transportation Engineering Agency of the Military Traffic Management Command (MTMC-TEA). Their analysis includes movement within the continental United States (CONUS), strategic deployment movement outside the continental United States (OCONUS), and the required movement inside the theater of operations. Elements considered include the type and quantities of transportation (ships, railcars, aircraft (A/C), etc.) needed to transport the unit over each leg of the deployment, plus considerations of the relative scarcity of the assets required. The final product provided is a relative ranking of the systems being analyzed, on a scale of +100 to –100. Each system is compared to the system its is replacing. The ranking is based on the differences in transportation assets necessary to move a unit or force to a generic OCONUS location. If more assets are needed, the score is negative. If fewer assets are needed, the score is positive. If a system does not have a predecessor, the ranking is based on the assets needed to move it. For example, suppose system A is replacing system B. It takes five C-5s to transport a unit's worth of system B to a theater, but it takes only two C-141s to transport system A. System A would have a positive score.

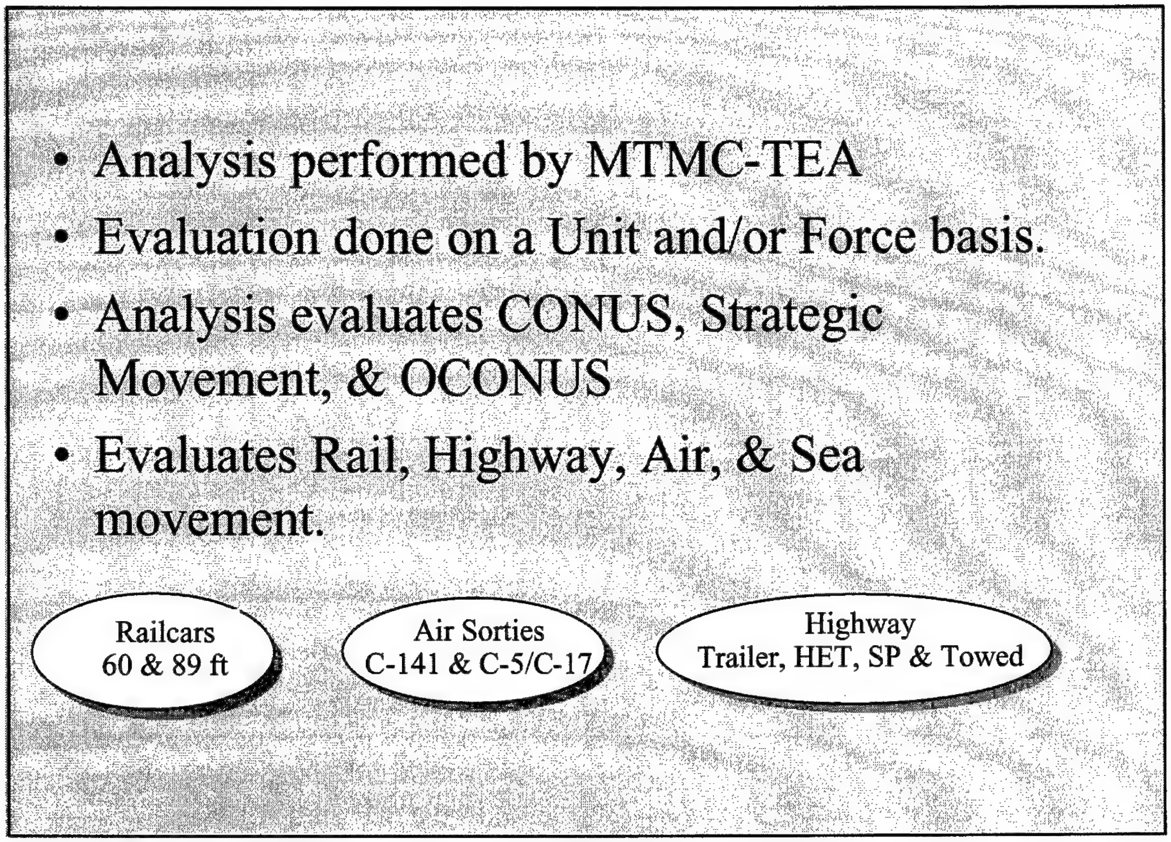


Figure 9. Deployment Analysis

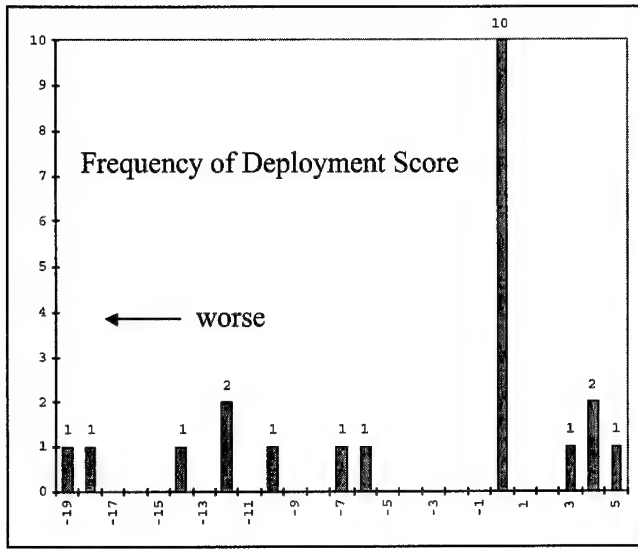
Figure 9 provides the parameters of the deployment analysis. The circles indicate the types of transportation equipment that are available, including railcars, aircraft, trailers, heavy equipment transporter (HET), self-propelled equipment (SP), and towed equipment.

2.6 Deployment Results

Improving

	BASE	NEW	RATING
7	AH64A	COMMANCHE	5
8	AH64A	AH64D	4
15	PAC2	MEADS	4
12	M198	HIMARS	3
1	M1A1	M1A2	0
2	BFVA2	BFV OIDS	0
4	TOW	FOTT	0
11	MLRS	ILMS	0
13	FIREFINDER	FFP3I	0
14	PAC2	PAC3	0
16	AVENGER	SLEW-TO-CUE	0
19	HEMTT	HEMTT II	0
20	CH47	CH47D	0
24	HUMWV	LRAS3	0
17	NONE	SENTINEL	-2
18	5TON TRUCK	FMTV	-2
23	TAILBLAZER	GBCS	-2
6	NONE	E-FOGM	-6
22	AVLB	WOLVERINE	-7
10	FISTV	BFIST	-10
3	BFVA2	BFV A3	-12
5	NONE	LOSAT	-12
25	HUMWV	FSCS	-14
9	PALLADIN	CRUSADER	-18
21	CEV	GRIZZLEY	-19

Decreasing



Rating is on a +100 to -100 scale

Figure 10. Deployment Results

Figures 10 and 11 display the results of the deployment analysis. The base set of systems are the predecessors. A score greater than zero indicates that the modernized system is more easily deployed than its predecessor. Note that a large number of systems have no significant impact on deployment. Also note that a large number of the modernized systems have a negative effect on deployment. These systems are generally larger and heavier than their predecessors.

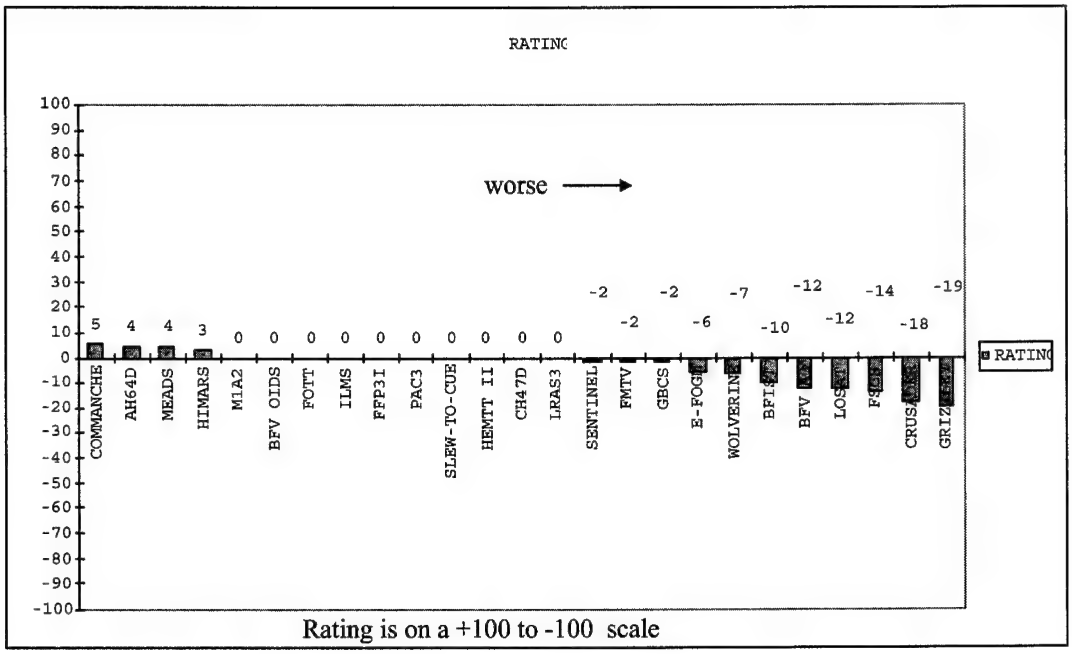


Figure 11. Relative Impact

Figure 11 shows the relative impact on deployment of the modernized systems. The systems to the left are easier to deploy than their predecessor system while the systems on the right are more difficult.

2.7 Combat Effectiveness Submodule

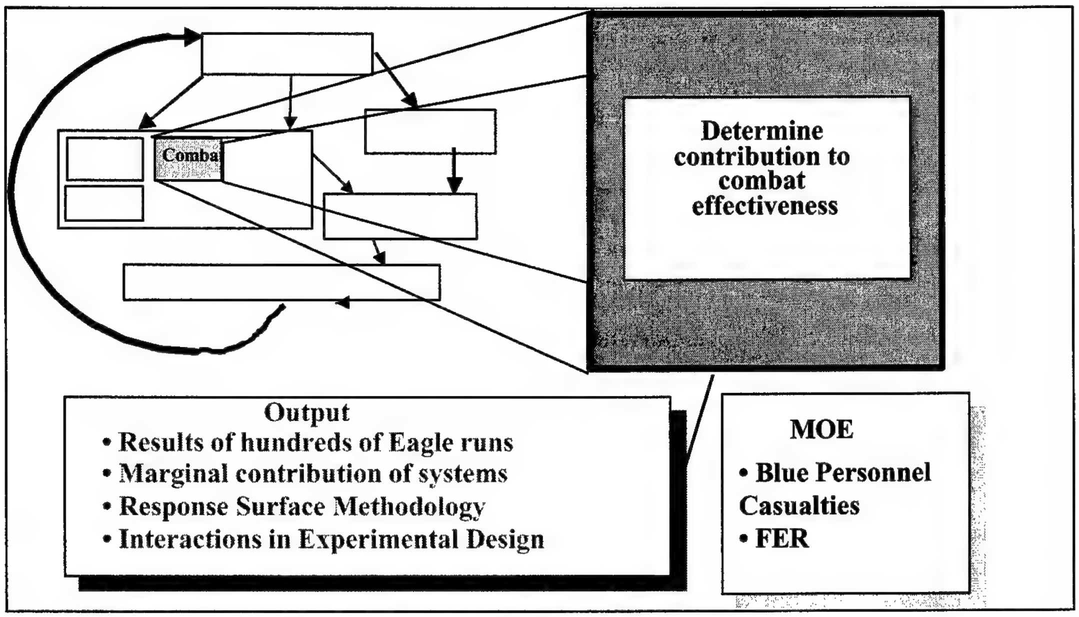


Figure 12. Combat Effectiveness Submodule

The combat modeling supporting the VAA process is the most time-intensive section of the methodology. It consists of a designed experiment to estimate the increased performance of a corps equipped with a system over a corps equipped with the system's predecessor. A Plackett-Burman experimental design is used to generate which combinations of systems are included in each individual combat run. The purpose of using such an experimental design is to minimize the number of iterations needed to achieve the goal of extracting the main system effects from the corps combat runs. These main effects are used in a linear additive model with Red/Blue fractional exchange ratio (FER) and Blue personnel casualties (BPC) as the primary measures of effectiveness (MOE). The corps-level model (Eagle) was used as the combat simulation for VAA 5. For a detailed explanation of the experimental design, see the CAA technical paper Experimental Design with Combat Models (XD Combat), CAA-TP-92-9.

2.8 Combat Results Distribution

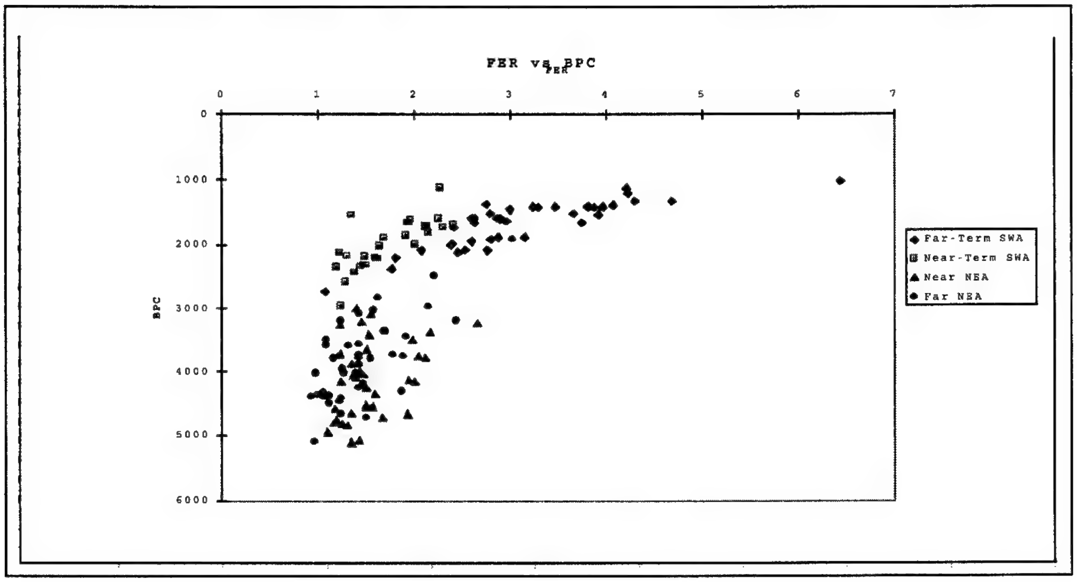


Figure 13. Combat Results Distribution

Figure 13 shows the MOE scores for the combat model runs, broken out by scenario and timeframe. A score that is higher and to the right is considered preferable, as this would have a higher FER and a lower BPC score.

NEAR

Deployability	NEA BPC	NEA FER	SWA BPC	SWA FER
COMANCHE	HAB	TAC_UAV	MSTAR	MSTAR
AH-64D	GRCS	MSTAR	ATACMS_IIA	GRCS
MEADS	PAC_3	HAB	PAC_3	ATACMS_IIA
HIMARS	FF_P3I	BSFV_E	IEWCS	LRAS3
	BSFV_E	PAC_3	HIMARS	PAC_3
	BFV-A3	AH64D	STAFF	WAM
	TAC_UAV	BFV-A3	GRCS	STAFF

NEA BPC	NEA FER	SWA BPC	SWA FER
HAB	TAC_UAV	MSTAR	RAH_66
MEADS	HAB	ATACMS_IIA	ATACMS_IIA
BFV-A3	MSTAR	EFOGM	MSTAR
STAFF	STAFF	BDE_COMMS	EFOGM
TAC_UAV	M1A2_UPG	RAH_66	BFV_A3
AH64D	ATTCS	WAM	PAC_3
SLEW_TO	ILMS	ATACMS_II	BDE_COMMS

FAR

Relative Improvement by adding a CORPS worth of the system

Figure 14. Contribution to Scenarios

The systems listed in Figure 14 had a positive impact on the MOE in the scenario and timeframe and are listed in order of significance. For example, the HAB had a more significant impact than the TAC-UAV on Blue personnel casualties in the near-term NEA scenario. However, the TAC-UAV had a more significant impact on the FER than the HAB in the same scenario.

2.9 Effectiveness Integration Submodule

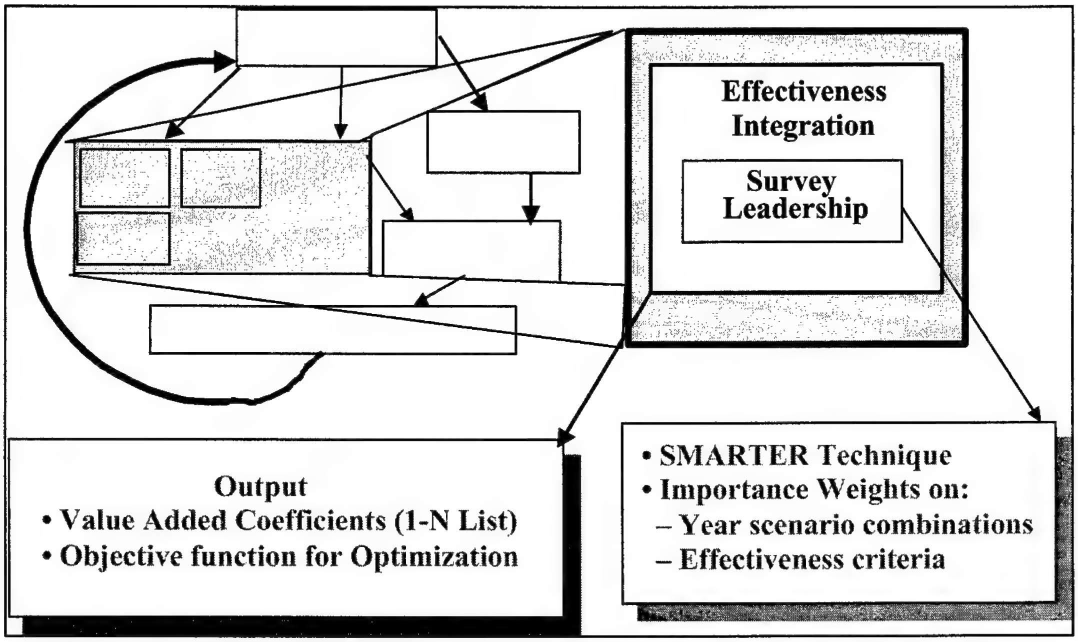


Figure 15. Effectiveness Integration Submodule

The submodules of the effectiveness module discussed previously generate a wide variety of MOE. These MOE are integrated into a single coefficient value per system by surveying the leadership of the Army. The most important part of this process is the emphasis in the survey on the ultimate goals of the Army as opposed to obtaining the surveyee's opinion on the relative importance of the candidate systems. By staying focused on the overall goals and allowing the generated MOE to be used to determine the relative rank of the systems, a more consistent and valid integrated ranking is obtained. These numbers are then used in the optimization module.

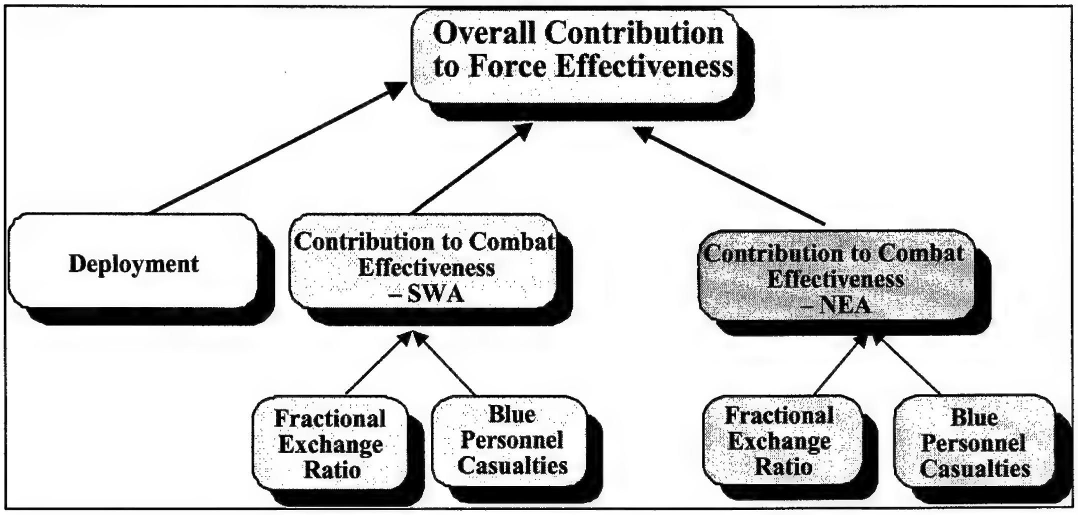


Figure 16. Value Hierarchy

Figure 16 is a pictorial representation of the value hierarchy used to determine the weights of the MOEs. As can be seen, for each scenario, FER and BPC are combined for the overall combat effectiveness measure. The combat measure is combined with deployment to get a scenario measure. Then the two scenario measures are combined to get an overall contribution for each system. This is done for each timeframe.

The weights are solicited at the lowest level of the hierarchy and then aggregated for the next level.

2.10 Survey Results

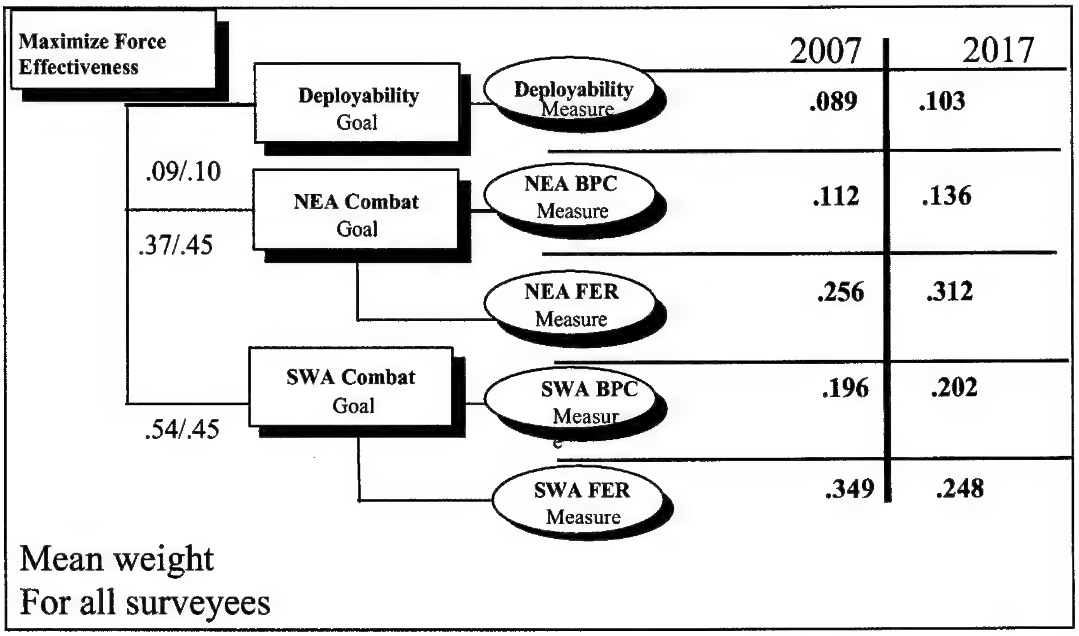


Figure 17. Survey Results – All Respondents

These are the average weights for each of the measures of effectiveness for all of the senior Army leaders that were surveyed. These weights are given for each level of the hierarchy depicted in Figure 16 for each timeframe. For example, at the second level of the hierarchy for the near term, the Army leadership considers combat effectiveness in Southwest Asia (SWA) to be most important, with a weight of .54 versus .37 and .09. This is not the case in the far term, where the weights for combat effectiveness for Northeast Asia (NEA) and SWA are the same. Also, in all cases, the FER is considered more important than the BPC. What must be remembered, however, is that these weights are in relation to the range of variation within the combat runs. They do not imply that the Army leadership considers Blue personnel casualties to be of less importance than winning the war.

	2007			2017		
	Mil	Civ	Aggregate	Aggregate	Civ	Mil
Deployability Measure	.116	.041	.089	.103	.056	0.129
NEA BPC Measure	.111	.114	.112	.136	.145	.131
NEA FER Measure	.221	.318	.256	.312	.268	.336
SWA BPC Measure	.191	.207	.196	.202	.249	.176
SWA FER Measure	.362	.325	.349	.248	.281	.229

Significant differences are circled

Figure 18. Military vs Civilian Results

Figure 18 highlights the differences between the military and civilian senior leaders that were surveyed.

2.11 Optimization Module

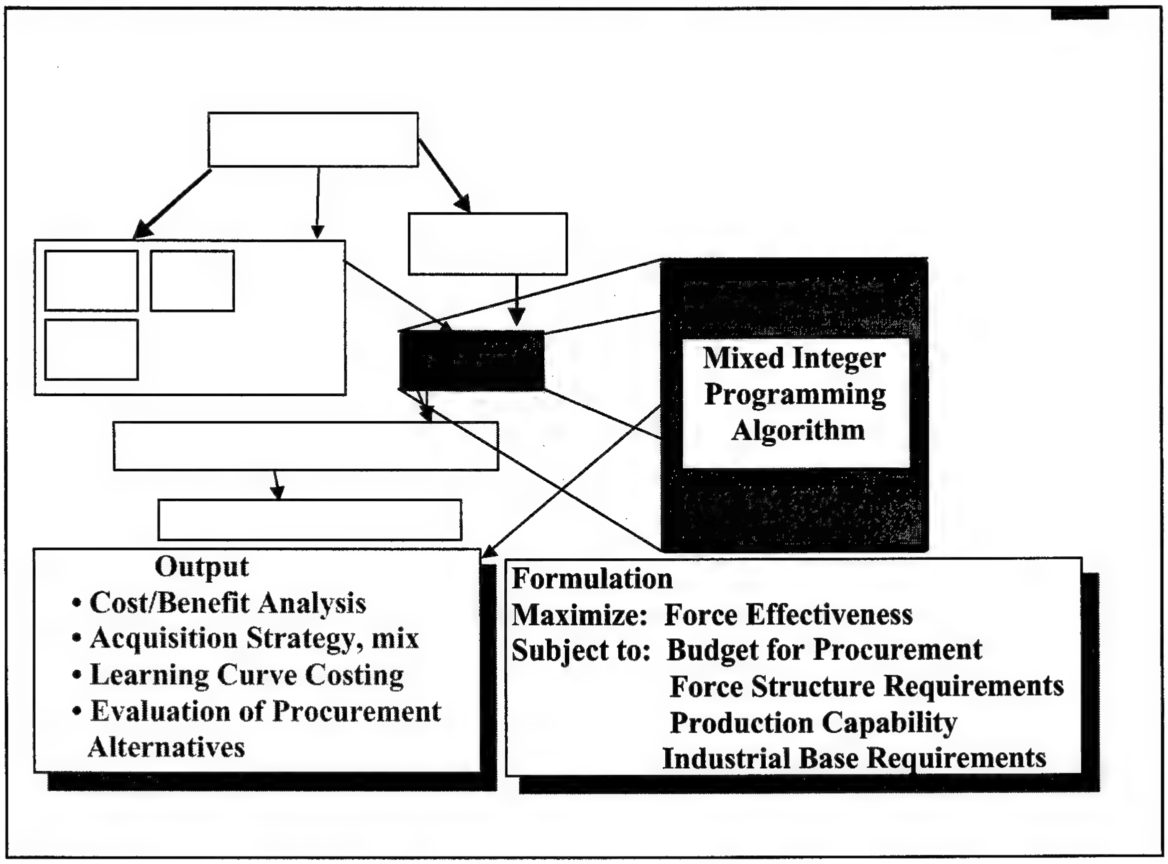


Figure 19. Optimization Module

The optimization module generates a recommended acquisition strategy for the systems under consideration, to include "don't buy" recommendations. This acquisition strategy is obtained from a mixed integer, linear programming optimization model, with the objective of maximizing the total effectiveness of the Army, as generated in the Effectiveness Module discussed earlier. This objective is constrained to meet the requirements of staying within the total obligation authority allocated to the systems under consideration, meeting the fielding goals obtained from the office of the Deputy Chief of Staff for Operations and Plans, staying within the ability of the production lines to produce the equipment, and finally taking any industrial base concerns into consideration.

2.12 Cascade of Acquisition Campaigns

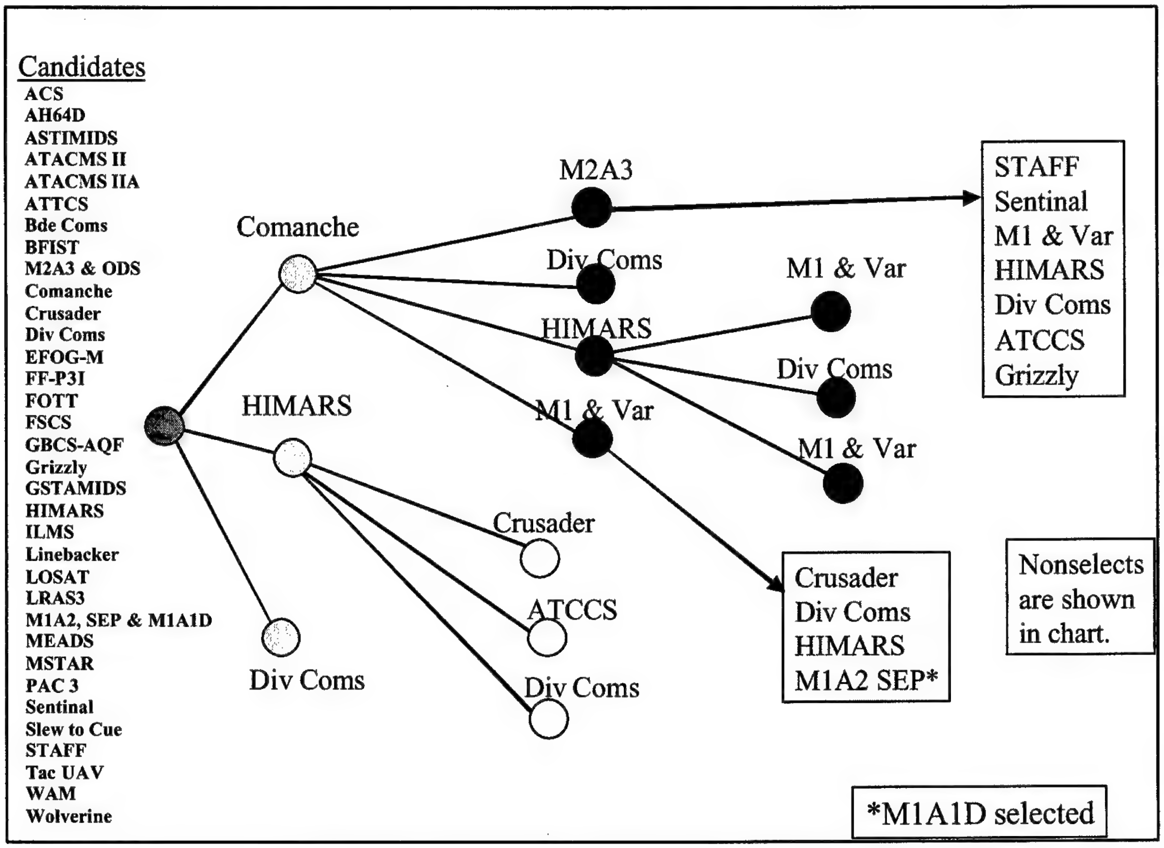
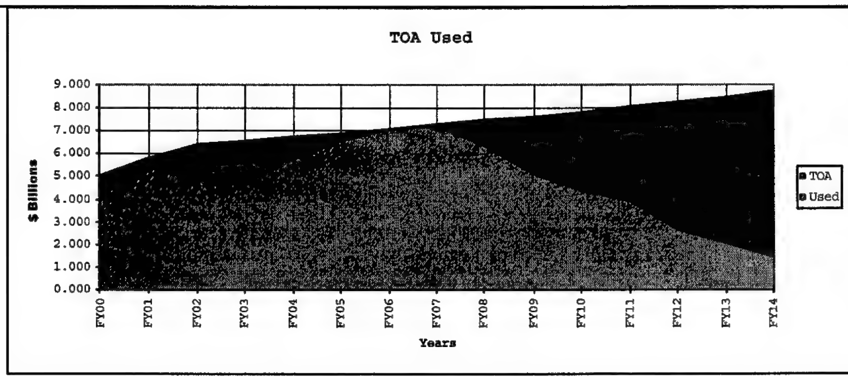


Figure 20. Cascade of Acquisition Campaigns

Figure 20 depicts the cascade of acquisitions strategies that were developed. This chart is read from left to right. As you progress from left to right, each node is a system that has been forced into the acquisition strategy with the exception of the leftmost node. The leftmost node is the initial run in which no systems were forced. If a node is to the right of the node for a system which has been forced in, that system was not recommended for procurement. In other words, if a system has a node on the tree, it was **not** recommended for procurement in the previous iteration. For example, following along the uppermost path in the tree we see that the initial model run, in which no systems were forced to be produced, recommended that the Comanche, HIMARS, and division communications not be procured. When the Comanche was forced to be procured, the model recommended that the M2A3, division communications, HIMARS, and the M1 & Variant not be procured. When the Comanche and the M2A3 are forced in, the STAFF, Sentinel, M1& Variant, HIMARS, division communications, ATCCS, and Grizzly are not recommended for procurement. Notice that the HIMARS was regularly not recommended, as can be seen by its frequent appearance on the chart. Also notice that, although brigade communications are always selected for procurement (no nodes on the tree), division communications are never selected (a node at every level of the tree).

For this iteration of Value Added Analysis, there was a variety of M1 tanks that could be procured. The possible combinations were: all new M1A2 tanks, new M1A2 tanks and M1A2 Seps, or new M1A2s and M1A1Ds. On Figure 20, if a node is annotated with M1 & Variant, none of these combinations was recommended for procurement. Although it cannot be seen on this figure, it should be noted that, when possible, the M1A2 by itself was recommended. However, when there was not enough money left in the budget for the M1A2 by itself, the M1A2/M1A1D or the M1A2/M1A2 Sep combinations were selected.

2.13 TOA Shortages



$ Billions

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
COMANCHE						-1.256	-1.426	-2.053	-0.956				
DIVCOMMS							0.000						
HIMARS							-0.058	-0.014					

Figure 21. TOA Shortages

Figure 21 depicts the TOA expenditures for the systems procured in the initial model run compared to the available TOA. From this figure, it can be seen that FY 05-FY 08 are the most constrained years in terms of funds available. The numbers in the lower chart show the amount of money necessary to procure that system in a particular year. For example, if you wanted to procure the HIMARS in addition to the other systems, an additional $0.058B in FY 06 and $0.014B in FY 07 would be needed.

Note: the cost in Figure 21 has been adjusted to reflect inflation (current dollars).

2.14 Concluding Remarks

The best value for the investment in digitization appears to be at the brigade level, followed by ATCCS, then division level.

HIMARS is the most commonly nonselected system because of the fact that it is produced in the same years as systems with a higher cost-benefit ratio.

An improvement to the M1A2 is consistently selected, M1A1D when funds are tight, and M1A2 SEP otherwise.

APPENDIX A PROJECT CONTRIBUTORS

1. PROJECT TEAM

a. Project Director

LTC Rodger Pudwill, Resource Analysis Division

b. Team Members

LTC Robert Alexander
MAJ Gary Harless

Ms. Linda Coblentz
Mr. Hugh Jones
Dr. Dong Kim
Mr. Giles Mills
Ms. Patricia Murphy

2. PRODUCT REVIEWERS

Dr. Ralph E. Johnson, Quality Assurance

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APPENDIX B REQUEST FOR ANALYTICAL SUPPORT

P *Performing Division:* RA *Account Number:* **97100**
A *Tasking:* Formal Directive *Mode (Contract-Yes/No):* No
R *Acronym:* **VAA 5**
T
Title: Value Added Analysis Phase V (POM 00-05)

1 *Start Date:* 25-Mar-97 *Estimated Completion Date:* 30-Nov-99
Requestor/Sponsor (i.e., DCSOPS): DCSOPS *Sponsor Division:* FD/PA&E

Resource Estimates: ***a. Estimated PSM:*** 23.6 ***b. Estimated Funds:***
c. Models to be Used:

Description/Abstract: Major support effort for the development of the 00-05 POM. Formal directives and SAG guidance TBD.

Study Director/POC Signature: **Original Signed** *Phone#:* 703-806-5364
Study Director/POC: **Ms. Linda Coblentz**

If this Request is for an External Project expected to consume 6 PSM or more Part 2 Information is Not Required. See TAB C of the Project Directors' Guide for preparation of a Formal Project Directive.

Background:
P
A
R *Scope:*
T
2
Issues:

Milestones:

Signatures *Division Chief Signature:* ***Original Signed and Dated*** *Date:*
Division Chief Concurrence:
Sponsor Signature: ***Original Signed and Dated*** *Date:*
Sponsor Concurrence (COL/DA Div Chief/GO/SES):

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